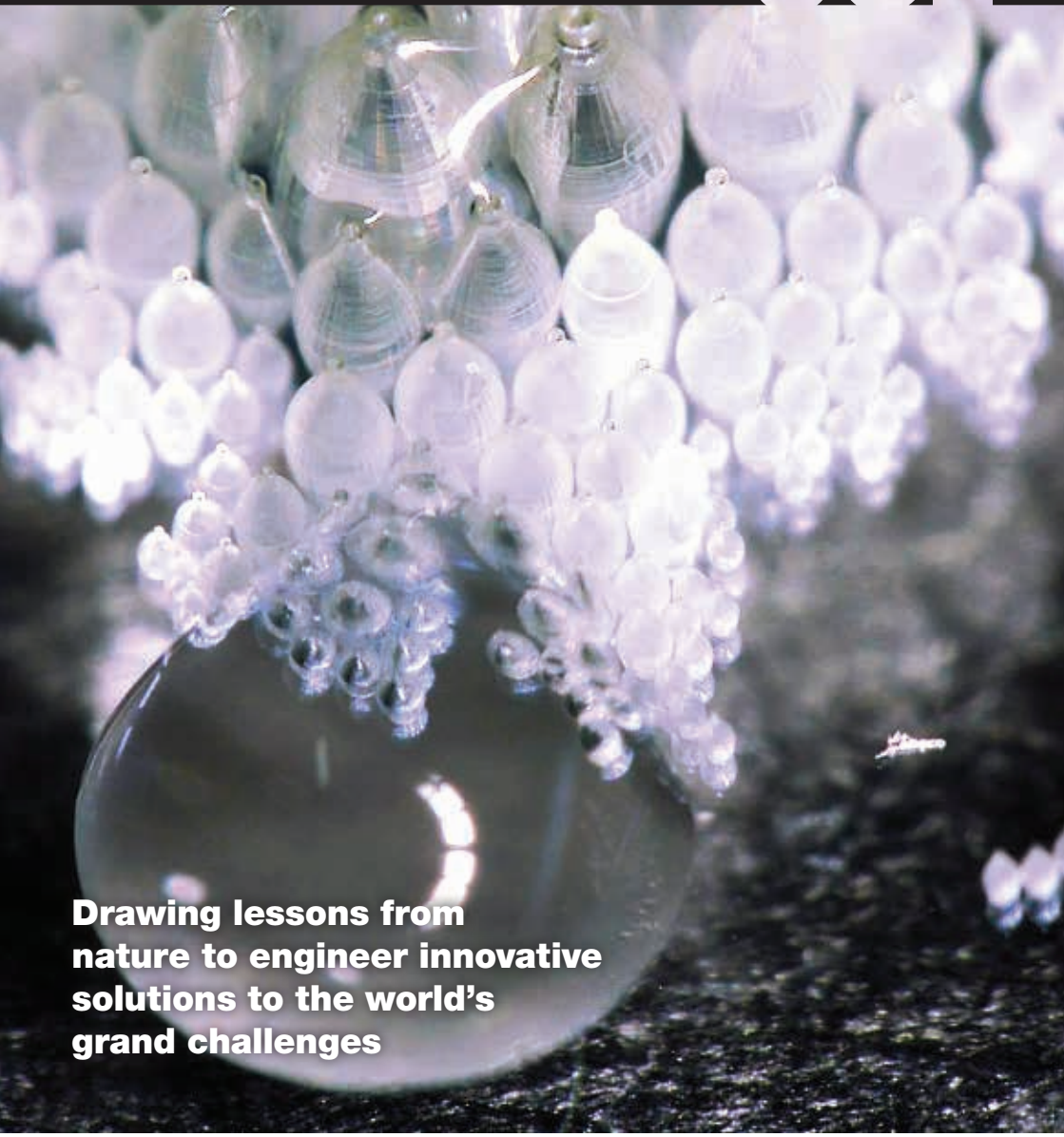
CENTRE FOR NATURE INSPIRED ENGINEERING
UCL DEPARTMENT OF CHEMICAL ENGINEERING

UCL



Drawing lessons from nature to engineer innovative solutions to the world's grand challenges

UCL ENGINEERING
Change the world

EPSRC
Engineering and Physical Sciences Research Council

CfNIE Centre for Nature Inspired Engineering

Contents

Front cover image:
"Aquaphile - Elixir of Life"
by Malica Schmidt, CNIE PhD candidate in Chemical Engineering and Architecture. Winner of the People's Choice, UCL Research Images as Art Competition 2019.

The Centre for Nature Inspired Engineering (CNIE) at UCL draws lessons from nature to engineer innovative solutions to our grand challenges in energy, water, materials, health, and living space.

In 2013 at the Royal Academy of Engineering Global Grand Challenges summit, the Centre received a £5M "Frontier Engineering" Award from the EPSRC, one of only five such Awards in the UK. In 2019, the continuation of the Centre was assured by an EPSRC "Frontier Engineering: Progression" Award.

EPSRC

Engineering and Physical Sciences Research Council

Centre Overview

Nature is a treasure trove of ideas to find transformative solutions to our Grand Challenges.

CfNIE Centre for Nature Inspired Engineering

www.natureinspiredengineering.org.uk

@UCLCNIE

The Centre for Nature Inspired Engineering draws lessons from nature to engineer innovative solutions to our grand challenges in energy, water, materials, health, and living space. It focuses on the discovery and application of fundamental mechanisms behind desirable traits in nature (such as scalability, efficiency or robustness) that can be applied to enable transformative solutions to challenging engineering problems, such as those pertaining to the UN Sustainable Development Goals or the UK's Industrial Strategy.

Using theory and simulation-assisted rational design, complemented by experiments, synthesis and testing, the Centre unites a highly interdisciplinary team of researchers, from the life sciences and computer science to chemical and materials engineering, medicine, and architecture. Collaborations with a wide range of industrial partners allow us to accelerate the translation of research findings into practice.

Our People

Marc-Olivier Coppens

CNIE Director

In 2013, Professor Marc-Olivier Coppens led the Centre for Nature Inspired Engineering in a bid to win an EPSRC "Frontier Engineering" Award. As well as being Director of the CNIE, he has held the position of Ramsay Memorial Professor and Head of the Department of Chemical Engineering at UCL since 2012.

Awards for his pioneering research on nature-inspired chemical engineering (NICE) include Young Chemist and PIONIER Awards from the Dutch National Science Foundation (NWO), an RSC Catalysis Science and Technology Lecture Award (Zürich, 2012), the AIChE's Particle Technology Forum's PSRI Lectureship Award in Fluidization (USA, 2017), and several invited named lectureships and visiting professorships in the USA, Norway, China and Turkey. He is a Chartered Engineer, Fellow of IChemE (2014), AIChE (2016), and Member of the Saxon Academy of Sciences, Germany (2018). In 2017, he was also appointed Qiushi Chair Professor at Zhejiang University in Hangzhou, a leading Chinese university.

He is Editor-in-Chief of Chemical & Engineering Processing: Process Intensification, and serves on the Editorial Boards of Powder Technology, Diffusion Fundamentals, RSC Molecular Systems Design & Engineering, and the EMS Journal of Fractal Geometry.

Asterios Gavriilidis

CNIE Lead, Theme 1

Asterios Gavriilidis is a Professor of Chemical Reaction Engineering at UCL, where he joined in 1993. He has long-standing expertise on catalytic reaction engineering, and his group has developed a range of intensified reactors, such as coupled catalytic plate reactors, mesh reactors, rotating disk reactors, membrane reactors for applications in bulk chemicals as well as fine chemicals/pharmaceuticals.

Since 2000, he has been working in microreaction technology and micro process engineering, and it is this work that brought him to lead CNIE's theme on Hierarchical Transport Networks. It takes advantage of unique properties of miniaturised devices and the dominance of different forces in microscale for process intensification and obtaining information under well-controlled conditions. Currently, microreactors and millireactors are being developed for nanoparticle manufacturing for applications in healthcare (antimicrobial surfaces, cancer hyperthermia treatment, diagnostics). He is subject editor for Chemical Engineering Research and Design, Fellow of the IChemE, Chartered Engineer and UK representative in the Working Party of Chemical Reaction Engineering of the European Federation of Chemical Engineers.

Nigel Titchener-Hooker

CNIE Lead, Theme 2

Professor Nigel Titchener-Hooker, CEng, FIChemE, FREng, is Dean of UCL Engineering and was previously head of UCL Department of Biochemical Engineering. His research in the field of bioprocessing and synthetic biology led to his involvement in the CNIE as Theme Leader of Force Balancing.

Nigel directs the EPSRC Centre for Innovative Manufacturing of Emerging Macromolecular Therapies. This involves collaboration with an international consortium of 30 companies and is valued at over £45M.

As the first director of the Engineering Doctorate Centre for Bioprocess Leadership he managed a portfolio of over sixty doctorate programmes with companies spanning the whole breadth of the biotech industry. His particular research interests are centred on the delivery of whole bioprocess solutions and in particular the interface between unit operations. He pioneered studies in the area of process-business decision making and as Director of the Innovative Manufacturing Research Centre (IMRC) in Bioprocessing was closely involved with the creation of ultra scale-down tools for the evolution of process flowsheets for the efficient recovery and purification of high-value protein therapeutics.

Nigel has recently joined the Rosalind Franklin Institute as a Trustee.

Mark Miodownik

CNIE Lead, Theme 3

Professor Mark Miodownik is the UCL Professor of Materials & Society. He received his PhD in turbine jet engine alloys from Oxford University in 1996, and has worked as a materials engineer in the USA, Ireland and the UK. For more than fifteen years, he has championed materials research that links the arts and humanities to medicine, engineering and materials science. This culminated in the establishment of the UCL Institute of Making where he is Director and runs the research programme (instituteofmaking.org.uk).

Mark is a theme leader in the CNIE where he leads on self-assembly and self-repairing materials research within UCL and internationally. As a broadcaster and writer, he is internationally known for championing engineering and materials science: his TV programmes such as How It Works have reached millions of viewers globally; he is the author of the book Stuff Matters, a New York Times Best Selling book, which won the Royal Society Winton Prize in 2014 and the US National Academies Communication Award in 2015. In 2015 he was awarded the American Association for the Advancement of Science Prize for Public Engagement with Science. In 2017 he was awarded the Faraday Medal by the Royal Society and is a fellow of the Royal Academy of Engineering. In 2018, Mark was awarded an MBE in the New Year's Honours List for services to Science, Engineering and Broadcasting.

Eva Sorensen

CNIE Lead, Theme 4

Professor Eva Sorensen is a Professor of Chemical Engineering at UCL, and has been a member of the Centre for Process Systems Engineering (CPSE) since joining UCL in 1996. She has extensive experience within process systems engineering, particularly related to modelling, simulation, optimisation and control of fluid separations such as distillation, chromatography and membrane systems.

Her research focuses on exploring novel designs and operations based on a rigorous understanding of fundamental scientific principles, and by means of complex optimisation approaches. This makes her ideally placed to lead the CNIE's fourth new theme on Ecosystems, Control and Modularity, which will have a strong focus on exploring the translation of core mechanisms to process intensification and manufacturing, whilst expanding the interface between process systems engineering, computer science, genetics and biochemical engineering, aiming to create robust, adaptive, bioinspired supply networks.

She is Editor-in-Chief of Chemical Engineering Research & Design, a chartered scientist (CSci), a chartered engineer (CEng), a Fellow of the IChemE (FIChemE), the UK representative on the Working Party on Fluid Separations of the European Federation of Chemical Engineering (EFCE) (which she chaired 2007-2013), as well as a member of the IChemE's Fluid Separation Special Interest Group.

Application Area Leads

Richard Day

Biomedical and Healthcare Engineering

Prof Richard Day is a Professor in Regenerative Medicine and leads the UCL Applied Biomedical Engineering Group in the UCL Division of Medicine. His research activity focuses on developing and utilising novel material-based approaches to address unmet healthcare industry and clinical needs. Areas of research include antimicrobial resistance, cancer therapy, and regenerative medicine.

Marcos Cruz

Built Environment

Prof Marcos Cruz is a Professor of Innovative Environments and Director of the newly established multi-disciplinary MArch/MSc in Bio-Integrated Design at UCL. In 2008 he received the international RIBA President's Research Award. He has also been involved in architectural practice, having won numerous awards and first prizes in competitions, including the acclaimed Kunsthaus Graz with Cook and Fournier in Austria.

Founding co-investigators

Prof Daniel Bracewell
UCL Biochemical Engineering

Prof Dan Brett
UCL Chemical Engineering

Prof Richard Catlow
UCL Chemistry

Prof Anthony Finkelstein
UCL Computer Science

Dr Sean Hanna
UCL Bartlett School of Architecture

Prof Alan Penn
The Bartlett - UCL's Faculty of the Built Environment

Prof Paola Lettieri
UCL Chemical Engineering

Prof Paul McMillan
UCL Chemistry

Prof Andrew Pomiankowski
UCL Biosciences

Prof Gopinathan Sankar
UCL Chemistry

Prof Philip Treleaven
UCL Computer Science

Prof John Ward
UCL Biochemical Engineering

Themes

"I would like to reiterate the quality of the work, research and mentorship that is coming from this centre. I continue to be impressed."

Ray Cocco – CNIE Advisory Board member and President and CEO, Particulate Solid Research Inc (PSRI)

CNIE research is grouped into four themes: (T1) Hierarchical transport networks; (T2) Force balancing; (T3) Dynamic self-organisation; (T4) Ecosystems, control & modularity.

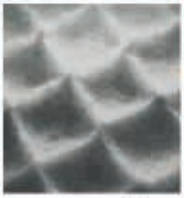
The unique feature of the CNIE is its thematic approach, based on ubiquitous, fundamental mechanisms in nature, which have evolved to induce exceptional performance for processes or systems that have parallels in engineering applications.

(T1) Hierarchical Transport Networks

The way nature bridges microscopic to macroscopic length scales in order to preserve the intricate microscopic or cellular function throughout (as in trees, lungs and the circulatory system).

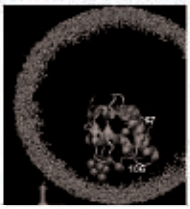
(T3) Dynamic Self-Organisation

The creation of robust, adaptive and self-healing communities thanks to collective cooperation and emergence of complex structures out of much simpler individual components (as in bacterial communities and in biochemical cycles).



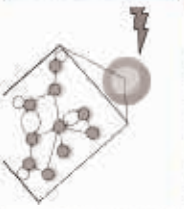
(T2) Force Balancing

The balanced use of fundamental forces, e.g. electrostatic attraction/repulsion and geometrical confinement in microscopic spaces (as in protein channels in cell membranes, which trump artificial membranes in selective, high-permeation separation performance).



(T4) Ecosystems, Control & Modularity

The control mechanisms and network properties underpinning the robustness, adaptability and scalability of many systems in nature, from metabolic networks to entire ecosystems.



Flagship Projects are carried out to validate this thematic approach, and simultaneously apply it to challenging engineering problems:

(T1)	Lung-Inspired Fuel Cells
(T2)	Bioinspired Membranes for Water Desalination and Bio-Separation
(T3)	Adaptive, Robust Materials and Architectural Spaces Inspired by the Dynamic Self-Organisation of Bacterial and Other Living Communities
(T4)	Rethinking Cancer Immunotherapy by Embracing and Engineering Complexity

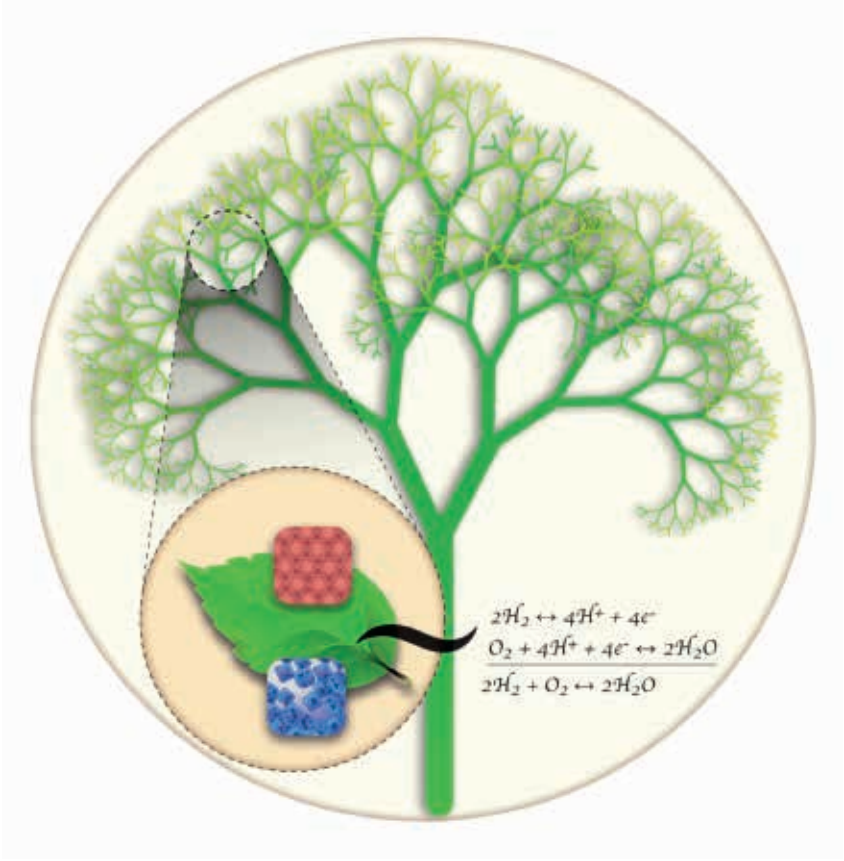
These problems are inherently cross-disciplinary and involve an unusual breadth of investigators, from chemical and biochemical engineering, chemistry, mechanical engineering and materials to computer science, architecture, medicine and beyond.

Theme 1 – Hierarchical Transport Networks

Our first theme draws inspiration from the way nature bridges microscopic to macroscopic length scales in order to preserve the intricate microscopic or cellular function throughout. Trees, the circulatory system, and lungs are examples of remarkably efficient and scalable hierarchical transport networks.

Projects under this theme aim to employ the nature-inspired engineering approach to realise optimal, hierarchical transport networks for applications related to energy, water, health, sustainable chemical production, and scalable manufacturing.

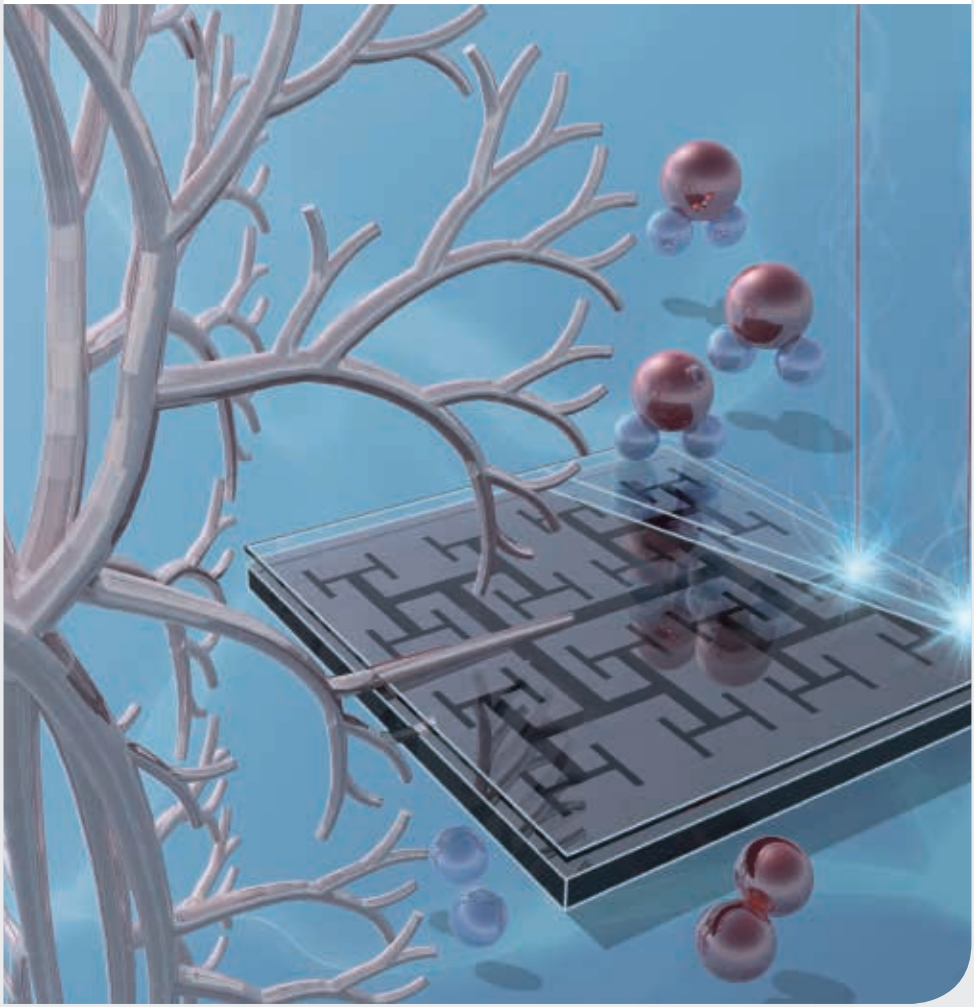
An example of the CNIE's work in this theme is to redesign fuel cell systems, in the context of renewable energy applications. Drawing inspiration from the human lung, we have designed, constructed and tested a fuel cell with globally optimized, hierarchical structure from nanomaterial to device level. The lung-inspired architecture combines attractive features that are translated to fuel cell design: an ability to bridge length scales, and facile scale-up – irrespective of size – increasing adaptability and durability while preserving microscopic function.



(P. Trogadas et al., Angew Chemie Int. Ed. 2016)

Research Activities within Theme 1

Main Project: Ensuring uniform gas distribution across the catalyst layer remains one of the on-going challenges impeding broader commercialisation of polymer electrolyte fuel cells (PEFCs). The unique characteristics of the lung are implemented into the design of lung-inspired flow fields for PEFCs, resulting in improved fuel cell performance and durability over conventional serpentine flow-field based fuel cells. Uniformity in reactant distribution and minimal pressure drop are retained during scale-up, demonstrating the robustness of the proposed nature-inspired approach across length scales.



(P. Trogadas, J. Cho et al., En. Env. Sci. 2018 - cover by M. Schmidt.)

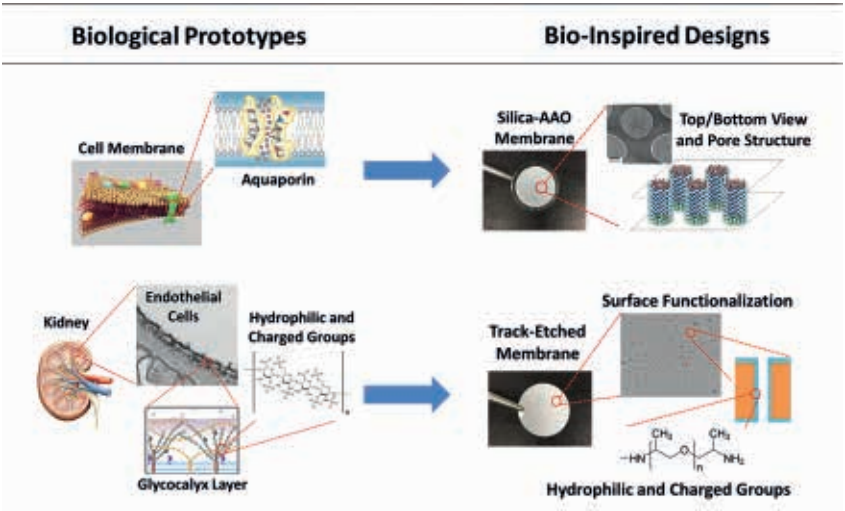
Theme 2 – Force Balancing

Theme two draws inspiration from the balanced use of fundamental physical forces down to the nanoscale, such as electrostatics and effects arising from geometrical confinement. One of the projects in this theme is the design and synthesis of chaperonin-inspired materials for enzyme immobilisation.

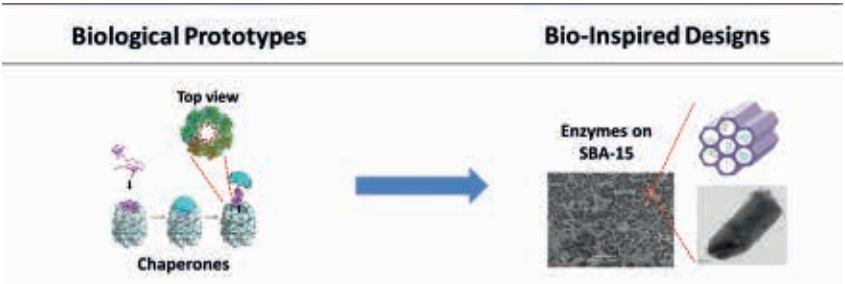
In nature, enzymes catalyse the reactions necessary for life. When cells undergo stress, like high temperature, they create multi-protein complexes, called chaperonins, to protect and stabilise enzymes. In order to use enzymes in pharmaceutical manufacturing, we design enzyme support materials based on these chaperonins. Both the nano-confinement and the electrostatic forces that are the basis for stabilisation of enzymes in the cavity of chaperonins are implemented in the nanoporous, non-biological materials we synthesise. This leads to increased activity and stability of the immobilised enzymes by force balancing in the nanopores.

Gaudí's Sagrada Familia Church in Barcelona is a great example of force balancing organic architecture.

Project 1: Features of biological membranes inspire the design and synthesis of an ordered hierarchically structured hybrid membrane (Aquaporin pore structure), with improved anti-fouling properties via the modification of hydrophilic and charged groups (Kidney endothelial glycocalyx). These membranes are used for bio-separation, nanoparticle sieving and water treatment.



Project 2: Inspired by the nano-confinement effects induced by chaperones on biological guest molecules, we design and synthesise optimised nanoporous materials as hosts for enzymes, for catalytic or therapeutic applications.



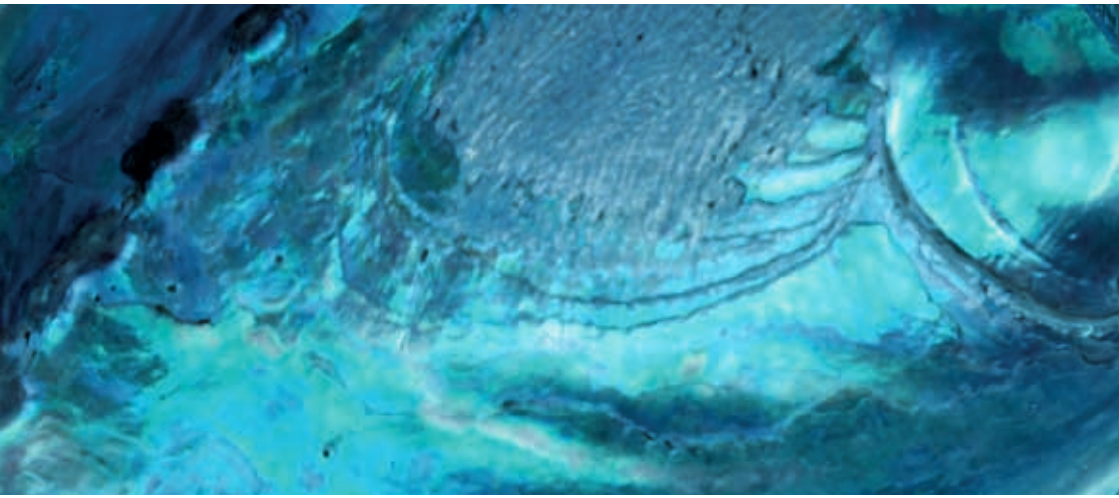
Theme 3 – Dynamic Self-Organisation

Our third theme draws inspiration from how pulsation or natural fluctuations induce structure, and how living organisms self-organise into communities and create structures that are resilient, adaptive and robust. Sources of inspiration include nacre in mollusc shells, adaptive bacterial communities, and the formation of ripples on sand dunes.

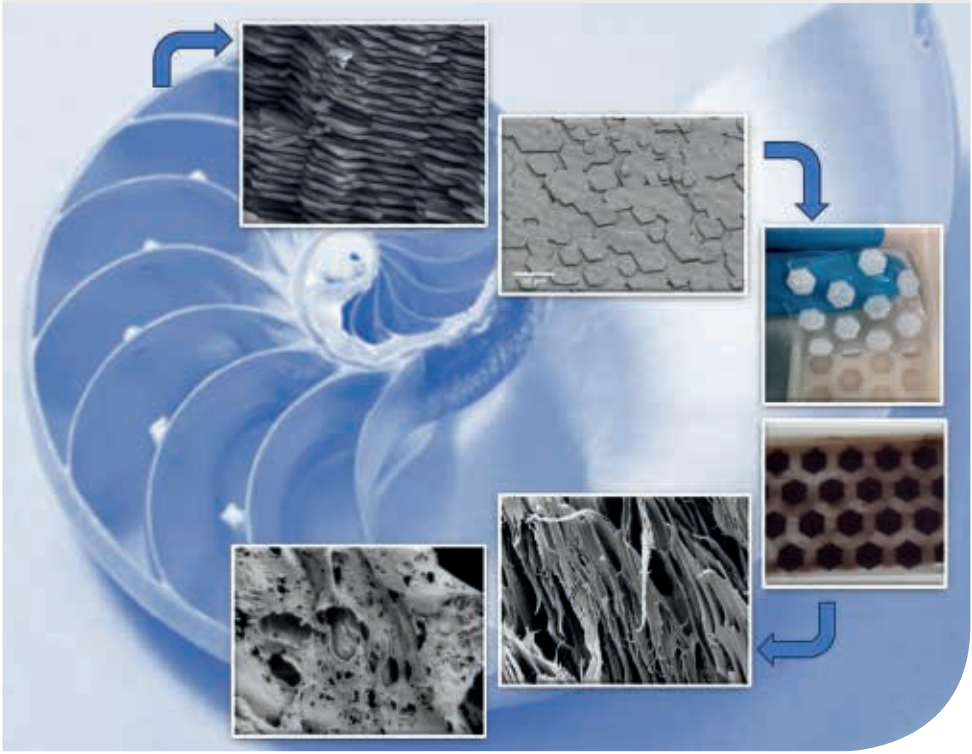
There are three major projects under this theme which focus on: pattern formation in pulsed fluidised bed reactors, creating and studying self-adaptive and self-healing materials, and agent based models inspired by bacterial communities.

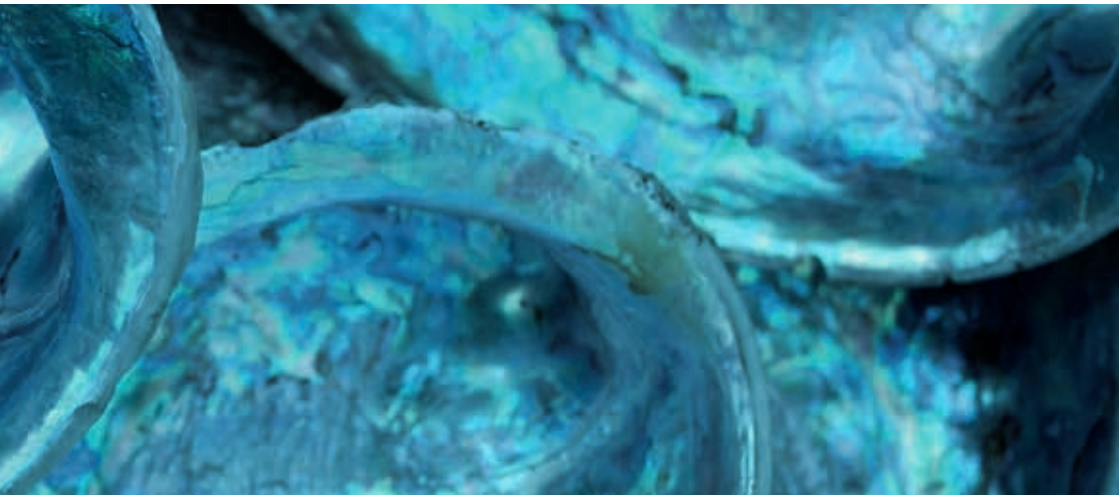
Research Activities within Theme 3

Project 1: We take guidance from the features resulting from the action of wind or waves on natural systems, such as sand dunes or beaches, to understand how periodic gas flows induce regular patterns in gas-solid fluidized beds, which otherwise display chaotic hydrodynamics. This not only transforms our understanding of multiphase flow, but can also be applied to avoid maldistribution in drying and reaction operations.



Project 2: Inspiration is drawn from the structure and function of nacre (i.e., iridescent layer on mollusc shells and pearls), to create biocompatible, magnetic actuators with self-healing ability, targeting biomedical and tissue engineering applications.





Theme 4 – Ecosystems, Control & Modularity

The new, fourth theme will implement network properties and control mechanisms that underpin resilience and adaptability in ecosystems and other natural networks, in applications ranging from catalysis to process intensification, medicine, and the built environment.

A new Flagship Project will explore the translation of core mechanisms to process intensification and manufacturing, while a further series of Inspiration Grants will expand the interface between chemical process systems engineering, computer science, genetics and biochemical engineering to build a strong, validated foundation for applications in other areas.

Project 1: Rethinking Cancer Immunotherapy by Embracing and Engineering Complexity

The human cell is an exemplary complex system – its global functions emerge from the constrained interactions among its numerous components (e.g. genes and proteins), as well as the environment (e.g. substrate stiffness and topography). This fact has important implications for cancer immunotherapy, where immune cells are harnessed as “living drugs” to fight cancer. Inspired by biocomplexity, this project aims to engineer biomaterials and cell processing hardware that integrate physical and biochemical cues for superior control over immune cell behaviour in immunotherapies.

Public Engagement & Activities

Outreach has been part of the CNIE from the beginning. This includes talks in schools, lectures and Q&A with 300 6th Form students and their teachers, the Nature Inspired Chemical Engineering Summer Challenge and active participation in the 'Women in Engineering Day'.

Presentation to GCSE and A-Level students

The CNIE's Nidhi Kapil, visited the North London Collegiate School to give a talk on, 'Supported Gold Nanoparticles for Catalysis', for 30 GCSE and A-Level students.

The school runs a weekly lecture programme, 'Science Café', providing a platform for GCSE and A-level science students to explore what is beyond their curriculum, sparking curiosity and interest towards future careers in Science and Engineering.

61st London International Youth Science Forum 2019

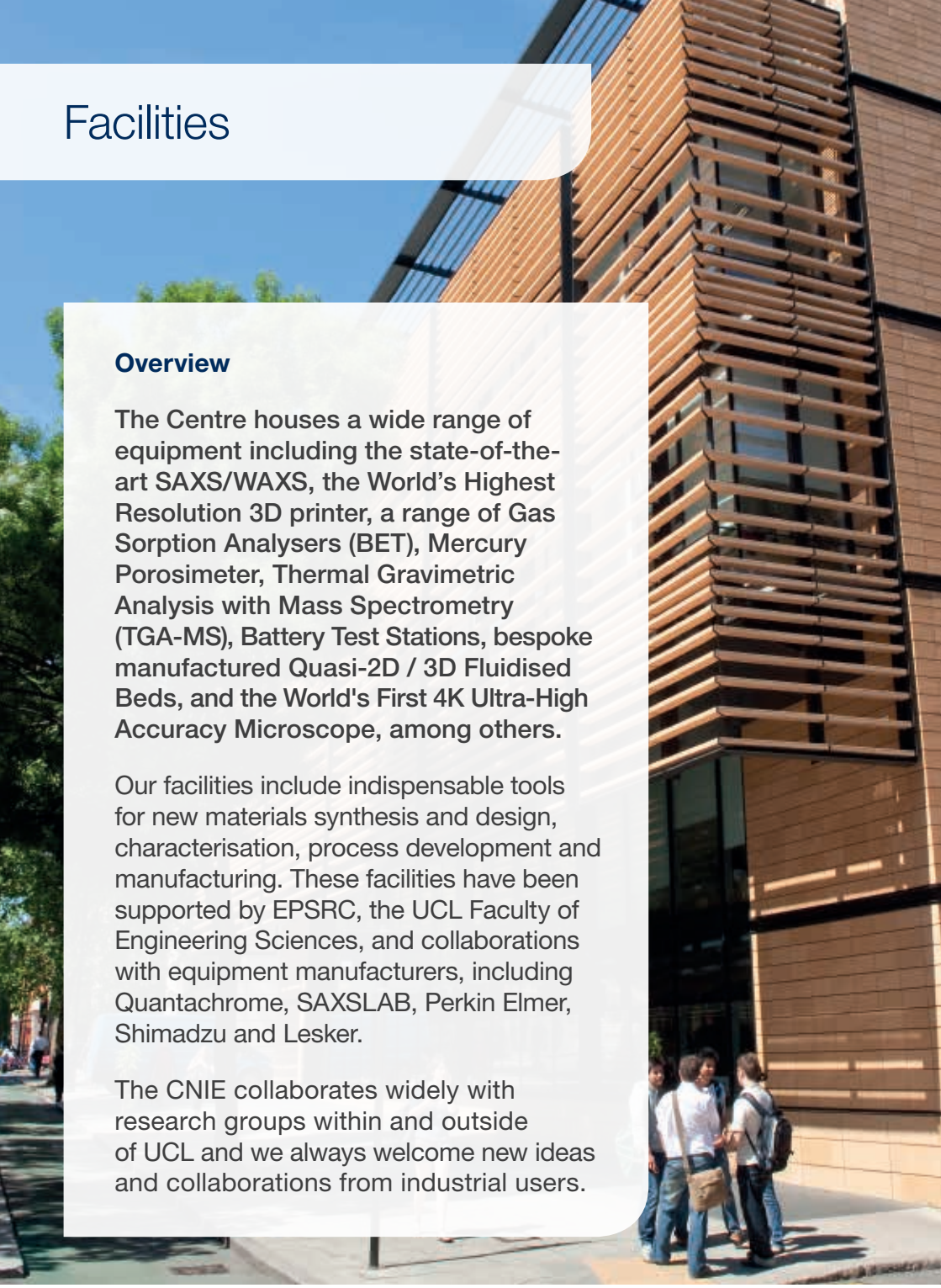
Professor Marc-Olivier Coppens was invited to be a speaker and facilitator at the "Science at the Interface" Specialist Study Day, at the LIYSF. The two-week residential event is held annually at Imperial College London and attracts 500 of the world's leading young science and engineering students aged 16-21 years old from more than 70 participating countries across six continents.

in2scienceUK is an award winning charity which empowers students from disadvantaged backgrounds to achieve their potential and progress to STEM and research careers through high-quality work placements and careers guidance, to which the CNIE offers yearly placements.

" Before undergoing this experience I truly believed that engineering was an industry filled with males. It also showed me how there are many different pathways to reach the end goal – many of the scientists I spoke to didn't have a degree in chemical engineering, but in different fields such as chemistry, computer science, physics and many more. This experience was very inspiring and led me to finalise my choice to pursue a career in science and it was truly unforgettable. I am very grateful for the opportunity I had."

Shantona Shahid
in2ScienceUK/TeachFirst student

Facilities



Overview

The Centre houses a wide range of equipment including the state-of-the-art SAXS/WAXS, the World's Highest Resolution 3D printer, a range of Gas Sorption Analysers (BET), Mercury Porosimeter, Thermal Gravimetric Analysis with Mass Spectrometry (TGA-MS), Battery Test Stations, bespoke manufactured Quasi-2D / 3D Fluidised Beds, and the World's First 4K Ultra-High Accuracy Microscope, among others.

Our facilities include indispensable tools for new materials synthesis and design, characterisation, process development and manufacturing. These facilities have been supported by EPSRC, the UCL Faculty of Engineering Sciences, and collaborations with equipment manufacturers, including Quantachrome, SAXSLAB, Perkin Elmer, Shimadzu and Lesker.

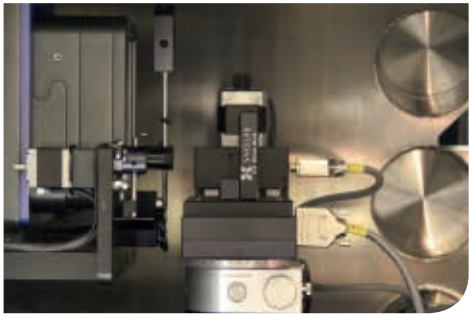
The CNIE collaborates widely with research groups within and outside of UCL and we always welcome new ideas and collaborations from industrial users.

Small/Wide Angle X-ray Scattering (SAXS/WAXS) Ganesha 300XL (SAXSLAB)

Introduction

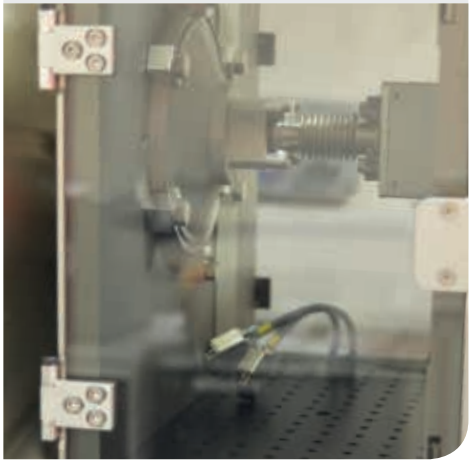
The CNIE at UCL has a unique in-house Small/Wide Angle X-ray Scattering (SAXS/WAXS) instrument called Ganesha 300XL. This state-of-the-art SAXS/WAXS is developed by SAXSLAB for CNIE with full motorization, extensive automation, large sample chamber and versatile sample area to provide a highly customised instrument for:

- Ambient work with up to 30 solid samples in a single run
- Temperature-dependent analysis between -100 and 350°C
- Solution scattering in refillable capillaries from 4 to 80°C
- GISAXS/GIWAXS Analysis
- Time-resolved Micro-fluidics monitoring in air
- q range 0.0025Å-1 to 3 Å-1, 2θ range 2° to 60°



SAXS provides essential information on the structure and dynamics of large molecular assemblies (polymers, colloids and porous materials) in various environments. It is a useful complementary technique to study complex systems such as:

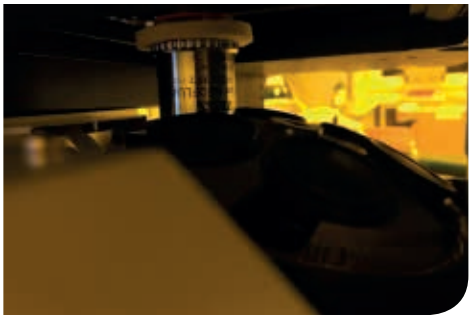
- Heterogeneous catalysts and adsorbents
- Membranes, thin films and interfaces
- Polymer processing/design
- Micro- and nano-fluidic systems
- Supramolecular organisation in biological systems
- Self-assembly of mesoscopic metal particles, colloids, liquid crystals and devices
- Distribution, adsorption and arrangement of nanoparticles, proteins or surface charges



Dr Han Wu (Research Lab Manager) manages the Small/Wide Angle X-ray Scattering (SAXS/WAXS) Ganesha 300XL (SAXSLAB) research facility

3D NanoPrinter

The Nanoscribe Photonic Professional GT is funded by an EPSRC grant obtained by Professors Ioannis Papakonstantinou and Marc-Olivier Coppens. The equipment is a high precision, high-resolution 3D printer capable of printing complex structures at a nano-level. It enables us to perform ground-breaking research across many different fields, including biomimetics, microfluidics and cell biology. Through direct laser writing, nature-inspired 3D structures can be fabricated to investigate a vast range of applications including properties of cell scaffolds and specific membranes. Using galvo technology, structures can be printed at high speed by an additive manufacturing layer-by-layer approach, or with the upmost precision using piezo technology.

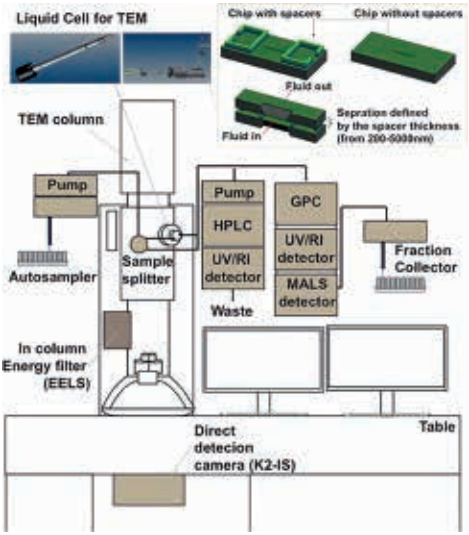


Key Features:

- CAD drawings can be easily imported in an STL file format
- Various UV-curable photoresists can be used, including common positive-tone resists
- Has a writing area of up to 100mm2
- Printing process can be monitored in real-time with a high-sensitivity microscope camera
- Can later apply casting techniques, such as Atomic Layer or Chemical Vapour Deposition and Galvanisation, to allow for the 3D replication of structures in silica, silicon, metals and PDMS.

EPSRC/JEOL Centre of Liquid Phase Electron Microscopy

Based in UCL Chemistry, the EPSRC/JEOL Centre of Liquid Phase Electron Microscopy was opened in 2017. This unique facility was funded by a grant by the EPSRC, led by Professors Giuseppe Battaglia, Ivan Parkin and Marc-Olivier Coppens, with additional support from JEOL, DENS Solutions, Gatan and UCL. The first-of-its-kind transmission electron microscopy (TEM) unit allows the imaging of samples in liquid phase with sub-nanometer spatial resolution and with sub-millisecond temporal resolution. The Liquid TEM will comprise of a TEM column equipped with an in-column filter and a direct detection camera as well as a liquid holder connected with several liquid handling units to allow for inflow analysis. Highest performance in-situ camera can resolve dynamic details in heating, catalysis, mechanical deformation, STEM diffraction, electrical testing, and chemical reaction experiments. This facility combines some of the newest developments in electron imaging to create a unit dedicated to liquid samples.



The facility builds across a range of applications involving soft matter, biomaterials, biological physics, synthetic biology, nanomaterials design and catalysis, enables the pioneering of new imaging techniques exploiting the unique liquid nature of the samples to establish Brownian 3D tomography techniques, and establishes high content correlative microscopy with automated chemical and physical analysis using inline chromatography and light scattering. The liquid TEM is capable of looking at the formation and evolution of structures in flowing liquids, including soft materials, cells and catalytic nanoparticles thus which will help us to characterise and develop new nature-inspired materials.

Visit the CNIE website for more details on our facilities
www.natureinspiredengineering.org.uk

Senior Research Technicians

Han Wu
Research Lab Manager

Han Wu earned a PhD in Chemistry from the University of Sheffield, and joined the CNIE as a senior research technician in 2013, and was promoted to research lab manager in 2018. Han is currently managing the research facility in the CNIE labs. She is also providing a wide range of research service to researchers at UCL and external users from industry. The service covers Small/Wide Angle X-ray Scattering (SAXS/WAXS) Analysis, Thermal Analysis (TGA and DSC), Porosity Analysis (BET, MIP and Pycnometer) as well as Imagining Analysis (High Speed Camera and DLS).

Barry Reid
Senior Research Technician

Barry works as a Senior Research Technician in the CNIE labs with an emphasis on 3D nano-printing. He is currently finishing up his PhD at UCL Department of Chemical Engineering, which focuses on block copolymer-directed assembly of mesoporous thin film architectures. He graduated with a first class honours in Analytical Science from Dublin City University in 2014 and also holds an honours degree in Finance and Economics. He has several years' experience in the financial, pharmaceutical and environmental analysis industries.

Ralph Hick
Senior Research Technician

Ralph Hick earned a PhD in Nanoscience from the University of Manchester. During his PhD he investigated both the synthesis of graphene and its application to supercapacitors alongside Prof Ian Kinloch and Prof Robert Dryfe. After working as a quality / analytical chemist in the metal finishing industry he joined the Department of Chemical Engineering at UCL as a Senior Research Technician. He supports the CNIE using his familiarity of both analytical instruments and research techniques.

Our Staff & Students

Yang Lan
Assistant Professor in Nature-Inspired Chemical Engineering

In 2019, the CNIE hired their first Assistant Professor, Dr Yang Lan. Dr Lan was previously a postdoctoral researcher at the Department of Chemical and Biomolecule Engineering, University of Pennsylvania, USA. He completed his PhD study at the Department of Chemistry, University of Cambridge, UK. Dr Lan's research revolves around colloids, supramolecular chemistry and interfaces, aiming to develop nature-inspired materials & systems for microchemical engineering.

Nidhi Kapil
CNIE PhD Student

" The platform provided to me by the CNIE is brilliant. The supervisor-led discussions in the first year contributed to invaluable insights into the breadth of research at the CNIE. I am privileged to get this exciting opportunity in collaboration with SABIC, an industrial leader to work on a very challenging project. My research involves the development of novel catalytic materials for the oxidation of propylene to propylene oxide, which is a reaction of great industrial importance. My PhD allows me collusion with the academic and industrial experts, whilst I am also given freedom to work and think differently. I enjoy being part of a multi-disciplinary research group where I have so much to gain and learn at every point."

Sasank (Viswanath) Bethapudi
CNIE PhD student with additional support from NPL

" I was first introduced to the CNIE through the NICE course during my MSc study at UCL. The course exposed me to various streams of the CNIE and I developed a special interest in nature-inspired fuel cells. The novelty and technical scope of the research on fuel cells within the CNIE motivated me to further my research interests into a PhD study. The CNIE is the most diverse and multi-disciplinary research group that I have ever worked with. The group provides me with a wide range of technical and intellectual capabilities that are of real support to my ongoing research."

Aleksandra Glowska

CNIE PhD Student, completing her studies between UCL and IPFEN, co-advised by Marc-Olivier Coppens and Elsa Jolimaitre

" I feel privileged to be a part of the CNIE and have the opportunity of working on a challenging topic for my PhD in collaboration with IFPEN, a renowned research institute in the field of energy, transport and the environment. My PhD involves the development of a multi-technique characterisation strategy of gamma-alumina in order to broaden the understanding of the structure-transport relationship of this catalyst support, widely applied in the petroleum and automotive industries. My PhD allows me to gain invaluable experience and skills as a researcher through working with academic and industrial specialists. The CNIE members have access to advanced and innovative physicochemical characterization instruments, which allow us to deliver high-quality research. I believe that the multi-disciplinary and pioneering character of research in the CNIE creates the perfect environment for exploring the breadth of cutting edge science and professional self-development."

Ayomi Perera

CNIE Lecturer in Organic and Pharmaceutical Chemistry at Kingston University

" As a PDRA at CNIE, I was able to delve into new research areas while a being a part of highly diverse and dynamic research group. Working with CNIE's extensive network of collaborators, both academic and industrial, allowed me to gain scientific insight into multidisciplinary and cutting-edge scientific frontiers, while sharpening employability skills. Access to a wealth of resources through state-of-the-art laboratories and facilities was influential in propelling my research into the next level, leading to multiple high-impact publications. The CNIE also provided opportunities to attend national and international conferences, and thus to keep up-to-date with current research while presenting my own, and to meet with world-class scientists from all over the globe. Moreover, opportunities to work with brilliant PDRAs and mentor talented MSc and PhD students was a highly rewarding, invaluable experience and prepared me for my current role as a lecturer in chemistry. The CNIE's continuous support together with the mentorship of Prof Coppens' is highly appreciated, while I build my own research group as an independent academic."

Victor Francia
Assistant Professor at Heriot-Watt University

" My time as postdoctoral research associate in the CNIE was a fantastic opportunity. The research, the mentorship and a strong interaction with other disciplines broadened my experience and gave me a unique skillset to transition from R&D into an independent academic career. The CNIE offers an exceptional environment for inter-disciplinary research. It encourages lateral thinking and the ability to cut across scientific fields to find efficient and integral technological solutions. These are key attributes of a modern, perhaps a more organic approach to innovation that I intend to pursue in my new research group focused on responsive technology."

Halan Mohamed
CNIE PhD on kidney-inspired membranes with support via EPSRC DTP

" Joining the CNIE for my MEng research project allowed me to discover that the research opportunities within the group represent a largely unexplored avenue for innovation in engineering. I received a great deal of support from both the group and my supervisors which helped me develop my work into the basis for my PhD. This would not have been possible if not for the calibre of researchers I was working alongside. My involvement also gave me an insight into the notable accomplishments of other students in the centre, and the opportunities for collaboration within a wider network of researchers. For these reasons, I decided to remain in the centre to do my PhD as I believed it to be the best place for me to develop my skill set as a researcher."

Michael Nigra
Assistant Professor of Chemical Engineering, University of Utah

" My time as a senior research associate in the Department of Chemical Engineering and the CNIE provided a unique and valuable experience before beginning my independent academic position at the University of Utah. Setting up a new laboratory, mentoring PhD students, and writing grant proposals were all extremely beneficial experiences to have when I applied for faculty positions. My transition in the summer of 2016 to the U. of Utah starting my own independent research group was also made much more facile by this preparatory experience at UCL."

Visitor Testimonials

Fabio Cardinale
Visiting MSc student, Politecnico di Milano

" My experience as a visiting MSc student in the CNIE was excellent. I received a huge amount of support from my supervisors and had the additional benefit of being able to use high-quality laboratory facilities. The staff members that I met were welcoming and supportive of my studies and were also very helpful with any administrative matters that needed attention. I am very thankful to have spent one year with an outstanding group of researchers who share both genuine interest in the subject matter and a desire to get the most out of it."

Chris Roberts
Visiting Undergrad, Wayne State University

" As an undergrad Chemical Engineering student from Detroit Michigan, I spent my summer under the direction of Professor Marc-Olivier Coppens and Dr Jason Cho studying PEM Fuel Cell Design at UCL. I conducted mechanical design analysis along with CFD Heat Flow for various gas channels. I learned to use ANSYS Mechanical and Fluent to study varied gas flows through custom made flow channels. During my time at UCL I was also exposed to group meetings and learned about the various projects being researched in the Nature-Inspired Engineering Group."

Broadening the Centre

Starting in 2015 the CNIE announced a call for "Inspiration" Grants to initiate new collaborative research projects between the UCL Centre for Nature Inspired Engineering, UK-based and international academic researchers, and industry.

To date the calls for "Inspiration" grants have led to 21 new, creative and cross-disciplinary projects, involving new partners from outside and inside UCL, thus welcoming broader participation for the Centre.

The grants encourage creativity to pump-prime projects with a nature-inspired engineering dimension, as well as exploration by teams of CNIE researchers of radically new ideas outside of main projects. The projects have resulted in a fantastic range of outputs and experiences

for researchers and PDRAs alike. The list of recently awarded Inspiration Grants (opposite) shows the cross-disciplinary nature and broad reach of the Centre, thanks to this approach.

" This six-month research project laid the groundwork for further investigation into the use of pulsation for particle processing and has outlined the potential benefits of using pulsating flow in crystallization processes."

Professor Asterios Gavriilidis,
Chemical Engineering, UCL

" We were delighted to receive the CNIE "Inspiration" Grant on the Self-Organising Built Environment. The grant encouraged a new team to get together to explore it in a concentrated burst. It is one thing for an urban researcher to be 'interested' in nature, or to cite scientific literature in a second-hand way, quite another to have zoologists and geneticists in your team. Bouncing ideas off colleagues from other universities in the UK and USA, and opening up seminars to everyone from artists to technologists and philosophers of science, is like a fulfilment of what a vibrant academic life should be about. The very existence of the CNIE was an inspiration: signalling that it could be worth investing in harnessing ideas from nature in a practical and scientific way. And being involved in this grant opened our eyes to new possibilities for further collaboration and exploitation of our research."

Stephen Marshall, *Professor of Urban Morphology and Urban Design, at the Bartlett School of Planning, and Inspiration Grant Awardee 2016*

" Initial findings were used to develop the successful EPSRC proposal "Novel intensified liquid-liquid contactors for mass transfer in sustainable energy generation" (EP/P034101), where the intensified jet mixers will be considered for both separations relevant to spent nuclear fuel reprocessing and biofuel production from renewable sources. It was extremely beneficial for the PDRA."

Professor Giota Angeli,
Chemical Engineering, UCL

2015 grants

- **Modelling hierarchical transport network of rocks using multiscale modelling and X-ray tomography (UCL/ Surrey)** – connects to new €3M EU grant by Prof. Striolo, on shale gas exploration with minimized environmental footprint, and research by Dr Faux and McDonald at Surrey
- **3D printing underwater: the regenerative marine fishing nets of salps (UCL/British Antarctic Survey)** – led by Dr Brenda Parker, UCL Biochemical Engineering with Dr Will Goodall-Copestake (BAS)
- **Bioactive aerogels: preclinical development of a novel bone grafting material (UCL/QMU/Straumann)** – led by Dr Niall Kent, CNIE PDRA; already led to support from RAE, EPSRC D2U, MRC and the Osteology Foundation

2016 grants

- **Pulsating flow inspired by blood circulation to improve fluid dynamics in flow (UCL/Strathclyde)** – led by Prof. A.Gavriilidis and involving Prof. C. Price at CMAC Future Manufacturing Research Hub
- **Robust self-healing fabrics for soft robotic applications (UCL/Harvard Wyss)** – led by Prof. Mark Miodownik and involving an entrepreneurial PhD student, plus connection to similar interests at Harvard
- **The self-organising built environment: Calibrating relationships across scales (UCL/Bristol/Edinburgh/ Oxford/SUNY)** – led by Prof. S. Marshall at UCL Bartlett School of Planning with collaborations in genetics

2017 grants

- **An applied, engineered oscillation inspired by the natural oscillatory behaviour of HIV (UCL/ University of Aberdeen)** – led by Dr Darren Nesbeth in UCL Biochemical Engineering
- **Growth of Iron Sulphide through Electrochemical Control: Towards Exploitation of Nature's Remediator, Catalyst and Electron Transfer Mediator (UCL/Loughborough University)** – led by Dr Katherine Holt, UCL Department of Chemistry
- **Nature Inspired 4D printing for biomedical applications (UCL/ Global Disability Hub)** – led by Prof Mark Miodownik, UCL Institute of Making with collaborations from UCL's Department of Computer Science
- **Nature-Inspired 'synthetic enzyme' for the oxygen reduction reaction (UCL/ Diamond Light Source)** – led by Dr Ryan Wang, UCL Chemical Engineering in collaboration with Dr. Rosa Arrigo, Beamline Scientist at Diamond Light Source
- **Bioactive Aerogels: Development of a Remineralizing Toothpaste Material (UCL / The Royal London Hospital)** – led by Dr Silo Meoto (CNIE PDRA) in collaboration with Dr Alessia D'Onofrio, The Royal London Hospital

2018 grants

- **Nature-inspired Self-healing Materials from Plastic Waste** – Led by Dr Lixu Yang, with Dr Stefan Guldin, UCL Department of Chemical Engineering in collaboration with the Adolphe Merkle Institute
- **Nature-Inspired Water Management in Polymer Electrolyte Membrane (PEM) Fuel Cell** – Led by Jason Cho, Department of Chemical Engineering, in collaboration with Helmholtz-Zentrum Berlin and Bramble Energy
- **Novel microfluidic chemotaxis platform for high-throughput bacterial viability quantification** – led by Dr Anand N.P. Radhakrishnan, UCL Department of Chemical Engineering with involvement from the Eastman Dental Institute and The London School of Medicine and Dentistry

2019 grants

- **Nature-inspired green, tunable and scalable synthesis of magnetic nanoparticles** – led by Dr Max Besenhard, UCL Department of Chemical Engineering, with support from UCL Physics and the University of Sheffield Chemistry Department
- **Nature-inspired 'cation channels' for all solid-state battery** – led by Dr Zhangxiang Hao, UCL Department of Chemical Engineering in collaboration with Imperial College
- **Mussel Inspired Chemistry and bacterially synthesised polymers for Oral Mucosal Adhesion and Drug Delivery** – led by Dr Nazanin Owji and Prof Jonathan Knowles in partnership with the UCL Eastman Dental Institute and Prof Roy at the University of Westminster
- **Microswimmer inspired microscale transport in complex fluids** – led by Dr Andreas Passos, UCL Mechanical Engineering, alongside Stavroula Balabani and Hermes Gadelha
- **Bubble Self-Organisation in Annular Gas-Solid Fluidised Beds: Transition from 2D to 3D structures** – led by Kaiqiao Wu, UCL Department of Chemical Engineering, in collaboration with Heriot-Watt University (Victor Francia) and PSRI (Ray Cocco)
- **Electrolytes in regulating protein-mimetic amphiphilic nanoparticles** – led by Dr Ye Yang, UCL Department of Chemical Engineering, alongside Dr Stefan Guldin and collaborating with the University of York
- **Investigating How Nature Inspired Hierarchical Structures Influence Cell Behaviour** – led by Dr Eseelle Hendow, and supported by Prof Richard Day in Centre of Precision Healthcare, UCL

Progression grant

In 2019, the CNIE was awarded a "Frontier Engineering: Progression" Award from the EPSRC, to support the continued growth and expansion of the Centre well into the next decade, enabling: implementation of a fourth Theme (T4) and continued growth of existing Themes (T1-3); the short-term retention of key research staff; growth of the Centre's national and international network of partners through the Inspiration Grant scheme; and, continued translation and impact of the Centre's research.

Marc-Olivier Coppens founding Co-Chair for UCL's Grand Challenge on Transformative Technology

Launched in 2016, the UCL Grand Challenge of Transformative Technology looks at how innovation and technology can have far-reaching benefits for society and the planet. The Grand Challenge funds cross-disciplinary work at UCL and with partner organisations, with a focus on priority themes of food, disability innovation, social impacts of new technology, data for good, and nature-inspired engineering.

This first ECI Conference on Nature-Inspired Engineering will bring together practitioners and researchers from academia, national laboratories and industry, with interest in nature-inspired solutions for engineering.

The conference will include a moderated panel discussion and workshop, focusing on applications of nature-inspired engineering and translation to practice, which will involve industrial participants and engage industrial-academic exchange. The conference is co-chaired by Professor Marc-Olivier Coppens, UCL, and Professor Bharat Bhushan, Ohio State University.

Keynote Speakers

Prof. Bharat Bhushan – *Ohio State University*

Prof. Marc-Olivier Coppens – *University College London*

Prof. Mark Cutkosky – *Stanford University*

Prof. Eugene Goldfield – *Harvard University*

Prof. Klaus Lackner – *Arizona State University*

Prof. Achim Menges – *University of Stuttgart*

Prof. Christoph Neinhuis – *TU Dresden*

Prof. Yongmei Zheng – *Beihang University*

Knowledge Transfer & Entrepreneurship

CNIE's Transformative Technology

The CNIE are proud to initiate transformative solutions to challenging problems in a wide range of areas, with great potential for societal impact. Some recent examples include:

Dental bone graft substitute materials and toothpaste
Dr Niall Kent, CNIE PDRA, and Dr Silo Meoto, former CNIE PDRA

Nature-inspired fuel cells and water management methods
Dr Jason Cho, CNIE PDRA

Coatings for applications for the International Space Station, and the built environment on Earth
Malica Schmidt, CNIE PhD student

New platforms for cancer immunotherapy
Matthew Chin, CNIE PhD student

Early Career Impact Award 2019

CNIE Postdoctoral Researcher, Dr Niall Kent won the Early Career Impact Award at the UCL Awards for Innovation and Enterprise 2019. This award recognises early career researchers who have contributed towards delivering research impact at UCL as part of acceleration activities.

The award was presented by UCL's Provost, Michael Arthur and Vice-Provost (Enterprise) Celia Caulcott for his work on Bioactive Aerogels with Professor Marc-Olivier Coppens. The material which Niall helped to develop and commercialise has the potential to improve dental health and is currently being used for bone grafting and other biomedical applications. (*Pictured: UCL Provost Michael Arthur, CNIE's Dr Niall Kent and UCL Vice Provost (Enterprise) Celia Caulcott)*

KTN NIS Special Interest Group

The Knowledge Transfer Network is building a new UK network, bringing together nature engineering solution providers and industry problem holders that could benefit from Nature-Inspired Solutions. The Centre is actively involved in this Special Interest Group (SIG).

"The CNIE is developing nature-inspired solutions to deliver new innovations in materials, structures and technologies. This links nicely to KTN's nature-inspired solutions special interest group in particular to find transformative solutions for the target sectors energy, transport and infrastructure."

Monika Dunkel, Knowledge Transfer Manager, KTN

Innovate UK
Knowledge Transfer Network

Collaborations

“ In our opinion, combining these nature-inspired solutions with our modern process tools and knowledge is likely to deliver a new impetus to innovation in the field of materials and structures.”
Eric Heintze (IFPEN, Director of Scientific Division)

“ Progress is more impressive each time. There is a lot of autocatalytic activity at your Center, Department and University. So it is always stimulating for me.”
David West (SABIC Fellow)

UCL Department of Computer Science

Nature-inspired Scientific Modelling, led by Philip Treleaven.

Work is taking place in two areas that fall under the heading of 'Nature-inspired Engineering':

a) Experimental scientific modelling; and

b) Biological computation.

Experimental Scientific Modelling

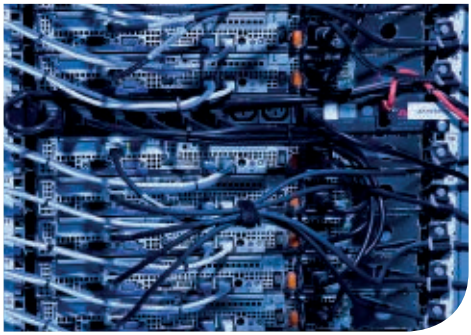
There are essentially two philosophies for scientific modelling:

- **Quantitative** – based on 'static' mathematical models (e.g. differential equations, computational statistics machine learning) and involving backtesting on historical data.
- **Experimental** – based on 'dynamic' natural science models (e.g. computational physics, computational chemistry) and involving the formation of hypotheses which are testable and falsifiable through experiment.

Biological Computation

Investigation is taking place about how information processing occurs in biology at the cell and DNA level, as opposed to the more traditional approach of studying information processing in the nervous system.

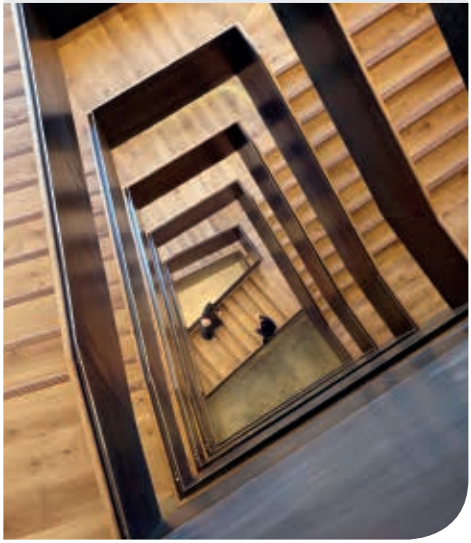
Besides attempting to understand how biology does information processing, we seek to ultimately investigate 'programmable biology' and build devices for applications such as programmable immunology.



UCL Bartlett School of Architecture

Architecture has taken the ideas from nature as a source of inspiration since Gaudí, Leonardo Da Vinci, and even earlier times. Nowadays, as printing technologies, and modelling and simulation tools advance, we go a step further and interdisciplinary collaboration takes place between the Chemical Engineering and the Bartlett School of Architecture. This unique chance from Chemical Engineering to integrate processes and laboratory work within the architectural framework has led to novel materials and prototypes.

One example of a specific project of this collaboration is a PhD thesis that develops a nature-inspired smart wall system that consists of nature-inspired smart building technologies. These technologies are able to self-clean, regulate humidity, circulate air, and therefore adapt to the changing requirements of any room in an energy efficient way.



IFPEN, France

IFP Energies Nouvelles (IFPEN) are a major research and training player in the fields of energy, transport and the environment. From research to industry, technological innovation is central to all its activities, structured around three strategic priorities: sustainable mobility, new energies and responsible oil and gas.

IFPEN has been collaborating with CNIE since 2016 on characterizing and modelling porous heterogeneous catalysts. Such catalysts can develop very complex porous structures, with porous organizations ranging from the nanometer to the millimetre scale. Moreover, spatial heterogeneity and anisotropy can be present at each organization level. The characterization of such catalysts is based on numerous physicochemical techniques, such as X-ray tomography and diffraction, nuclear magnetic resonance, nitrogen adsorption isotherms, electron microscopy, etc. However, none of these techniques gives access by itself to all the information necessary to understand and reconstruct the porous network in all its complexity.

IFPEN and CNIE work together to conceive a global multi-technique characterization strategy and to test its applicability on various industrial catalysts. This will then allow to correctly represent the porous catalyst structure through an appropriate pore network model that correctly accounts for intra-particle transport inside these structures under reaction conditions. The ultimate goal of this novel representation of the geometric structure of a porous medium and the intra-particle mass transport models are to include them in chemical engineering models for fixed bed reactors in order to predict the impact of diffusion on reactor performance. In the long term, this approach will allow to design the optimal structure of a catalyst that is required to achieve the desired reactor performance.

Marc-Olivier Coppens also became a member of the Scientific Board of IFPEN in 2018.

ECUST, China

East China University of Science and Technology (ECUST), one of the leading universities in the field of Chemical Engineering in China, has a Shanghai branch of the State-Key Laboratory of Chemical Engineering which is led by Professor Xinggui Zhou. Here the focus is on Reaction Engineering and Heterogeneous Catalysis.

Zhou's group in ECUST has been collaborating closely with the CNIE since 2014. The two groups share common research interests over hierarchical zeolites synthesis, catalytic application and catalysis-mass transfer interplay, with a particular emphasis on how mass transfer phenomena influence catalytic behaviour. The ongoing collaborations on mass transfer in zeolitic materials are based on both an experimental and theoretical modelling basis, and are backed up with novel methods to manipulate the architecture of zeolitic crystals. Together they supervised the PhD of Dr. Guanghua Ye – now Te Ping Associate Professor in ECUST.

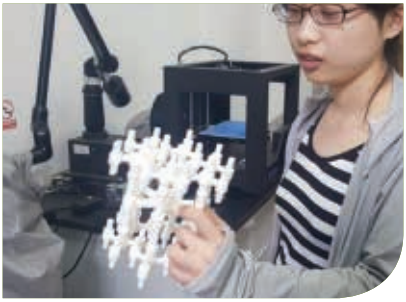
The collaboration has seen the joint publishing of 10 articles in peer reviewed journals such as ACS Catalysis, AIChE Journal, Chemical Engineering Journal, and Chemical Engineering Science. The collaboration between ECUST and the CNIE will continue to grow and flourish, and, more importantly, this link has become a pillar for enhanced cooperation between the two universities.

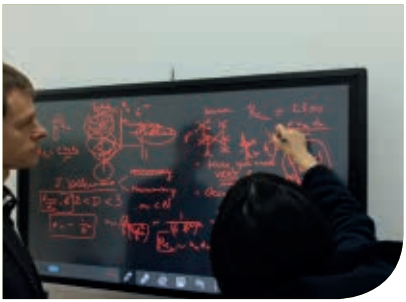
Zhejiang University, China

Zhejiang University (ZJU), established in 1897, is one of the very top-ranked comprehensive research Universities in China. Chemical Engineering was established at Zhejiang University in 1927. As the first Chemical Engineering Department in China, it houses three national key laboratories: State Key Laboratory of Chemical Engineering at ZJU, National Laboratory of Secondary Resources Chemical Engineering, National and Local Joint Engineering Laboratory for Industrial Biocatalysis.

Since 2016, the College of Chemical and Biological Engineering at ZJU has been collaborating with the CNIE in chemical process intensification and catalytic reaction engineering. The on-going collaboration explores the expansion to fluid/fluid processes, including more complex fluids like polymeric mixtures, and uses experimentation and computational fluid dynamics (CFD) modeling to find the optimal fractal dimension and other characteristics of the fractal injector, as a function of fluid/process parameters.

Prof. Marc-Olivier Coppens has been appointed as Qiushi Chair Professor of Zhejiang University. The collaboration between ZJU and the CNIE will become closer and extends from scientific research to education including undergraduate and graduate students, and short term exchanges. Shuman Xu has been awarded a Chinese Scholarship Council grant to join the NICE group as part of her PhD for one year in October 2019. Her work will be on 'The Nature of Surface Barriers to Transport in Zeolites'.





SABIC

SABIC, the fourth largest chemical company globally, has been collaborating with CNIE since 2015 in the development of new catalysts for partial oxidation reactions. One of the frontiers of heterogeneous catalysis is the use of single atoms or small clusters of metal atoms (e.g., 1-12 atoms).

Such sub-nanometer scale structures are capable of unusual transformations, catalytic activity, quantum size effects, etc. However, new methods are needed to synthesize and stabilize single atoms or small atomic clusters. SABIC is collaborating with CNIE in the development of nature-inspired methods for stabilizing atomic clusters. We hope that new materials from this program will enable breakthroughs indirect, selective, partial oxidations.

Nature-Inspired Engineering Course

UCL offers a module on Nature-Inspired Chemical Engineering for 4th year undergraduate and MSc students as part of their Chemical Engineering qualification, which has now been running for 5 years.

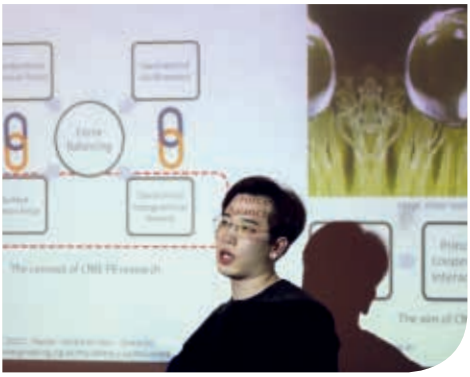
The course is taught by Professor Marc-Olivier Coppens, assisted by CNIE PhD students and PDRA's. The module aims to grow an understanding of ways to learn from solutions adopted by nature to solve similar issues in (chemical) engineering problems.

This is done by distilling the fundamental causes behind desirable features in the model natural system, and applying these to the technological system. The module aims to stimulate creative thought, and to engage students in coming up with innovative solutions by using the chemical engineering "toolbox" with a fresh pair of eyes.

As part of the module, students work in teams to develop a solution to an engineering problem using the Nature-Inspired Engineering methodology. They present their work at various points throughout the course in written and oral presentations, receive feedback, and complete the course with a report in the form of an Inspiration Grant proposal.

" Thanks for inspiring me during my time at UCL"
Sergio La Manno
(Now at ExxonMobil)

" I trust you are well, and still allowing students to feed off your knowledge about NICE, my encounters last year during my time on your module were truly inspirational"
Al-Khaled Said
(Now at Zebra Fuel Ltd)

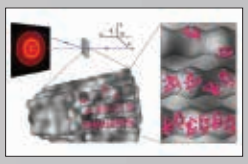


Journal Covers & Highlighted Publications

Angewandte Chemie - November 2015

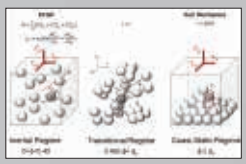
Chemical Engineering Journal - December 2017

Energy & Environmental Science - January 2018



A publication by J. Siefker et al. in the *J. Am. Chem. Soc.* titled, '**Confinement Facilitated Protein Stabilization As Investigated by Small-Angle Neutron Scattering**', was highlighted in the prestigious journal *Nature Nanotechnology.*

The 2018 publication '**A Lung-Inspired Approach to Scalable and Robust Fuel Cell Design**', which was published and made the cover of *Energy & Environmental Science*, was referenced in the opening issue of *Nature Catalysis* by Sir John Meurig Thomas.



Work on regular pattern formation in pulsed fluidised beds provides new insights into the fundamentals of gas-solid flows, crucial to industrial and natural phenomena alike. A new publication appeared in 2019 in a Special Issue of *Powder Technology* in honour of Prof. L.S. Fan.

An invited perspective article by A.S Perera and M.-O Coppens, titled '**Re-designing materials for biomedical applications: from biomimicry to nature-inspired chemical engineering**', appeared in a Special Issue of the oldest scientific journal, the prestigious *Philosophical Transactions of the Royal Society.* The Special Issue was on bioinspired materials and surfaces for green science and technology.

Special Issues

The IChemE/Elsevier journal *Chemical Engineering Research and Design (ChERD)*, are to publish a Special Issue on **Nature-Inspired Chemical Engineering** (Editors: Vincent Gerbaud and Catherine Xuereb (CNRS, Toulouse) and Marc-Olivier Coppens).

Another Special Issue will appear in the Royal Society of Chemistry's *Molecular Systems Design and Engineering (MSDE)* (Editors: Marc-Olivier Coppens and Bharat Bhushan (Ohio State University)).

Strategic Engagement

Robin Ramphal
Strategic Alliances Director

Robin Ramphal has been appointed as the Chemical Engineering department's Strategic Alliances Director, and supports the CNIE through industrial collaboration and strategic engagement.

Claire Saunders
Executive Assistant and CNIE Project Manager

Claire is executive assistant to Marc-Olivier Coppens, and is currently the project manager for the centre.

" We share CNIE's vision to develop transformative solutions to frontier engineering challenges, and value their nature-inspired approach to developing more efficient and effective technologies."

Jacob J. Thiart
Manager, Modeling and Scale-up – ExxonMobil

" The pioneering approach followed at the CNIE offers exciting potential to address issues faced by industry. In drawing inspiration from nature, researchers seek to apply fundamental mechanistic understanding to address complex industrial challenges."

Andrew Richards
CMC Leader – GlaxoSmithKline

" Professor Coppens' work has been of interest to us for many years and Johnson Matthey has been instrumental in initiating connections between the CNIE Group and the industrially led research consortium Eurokin."

Prof. E.H. Stitt
Scientific Consultant – Johnson Matthey

Original Industrial Support

Additional Support from Industry and National Laboratories, since inception

Location & Contact

UCL is London's leading multidisciplinary university, with more than 11,000 staff and 38,000 students from 150 different countries. Founded in 1826 in the heart of London, UCL was the first university in England to welcome students of any religion and the first to welcome women on equal terms with men.

The Centre for Nature Inspired Engineering is based within the Department of Chemical Engineering at University College London.

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London WC1E 7JE

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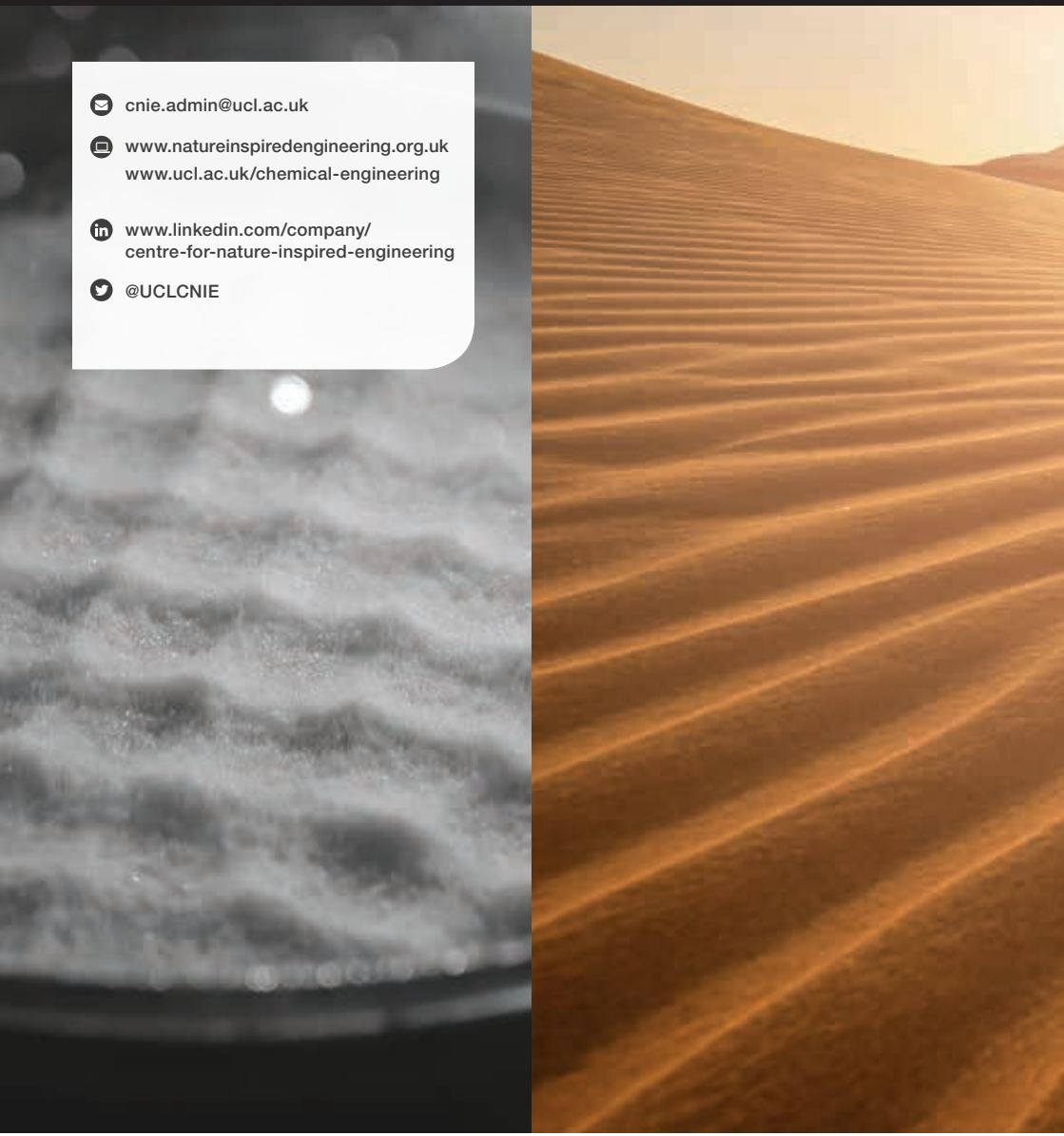
- @UCLCNIE



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www.natureinspiredengineering.org.uk
www.ucl.ac.uk/chemical-engineering

www.linkedin.com/company/
centre-for-nature-inspired-engineering

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UCL ENGINEERING
Change the world

EPSRC
Engineering and Physical Sciences Research Council

CfNIE Centre for Nature Inspired Engineering